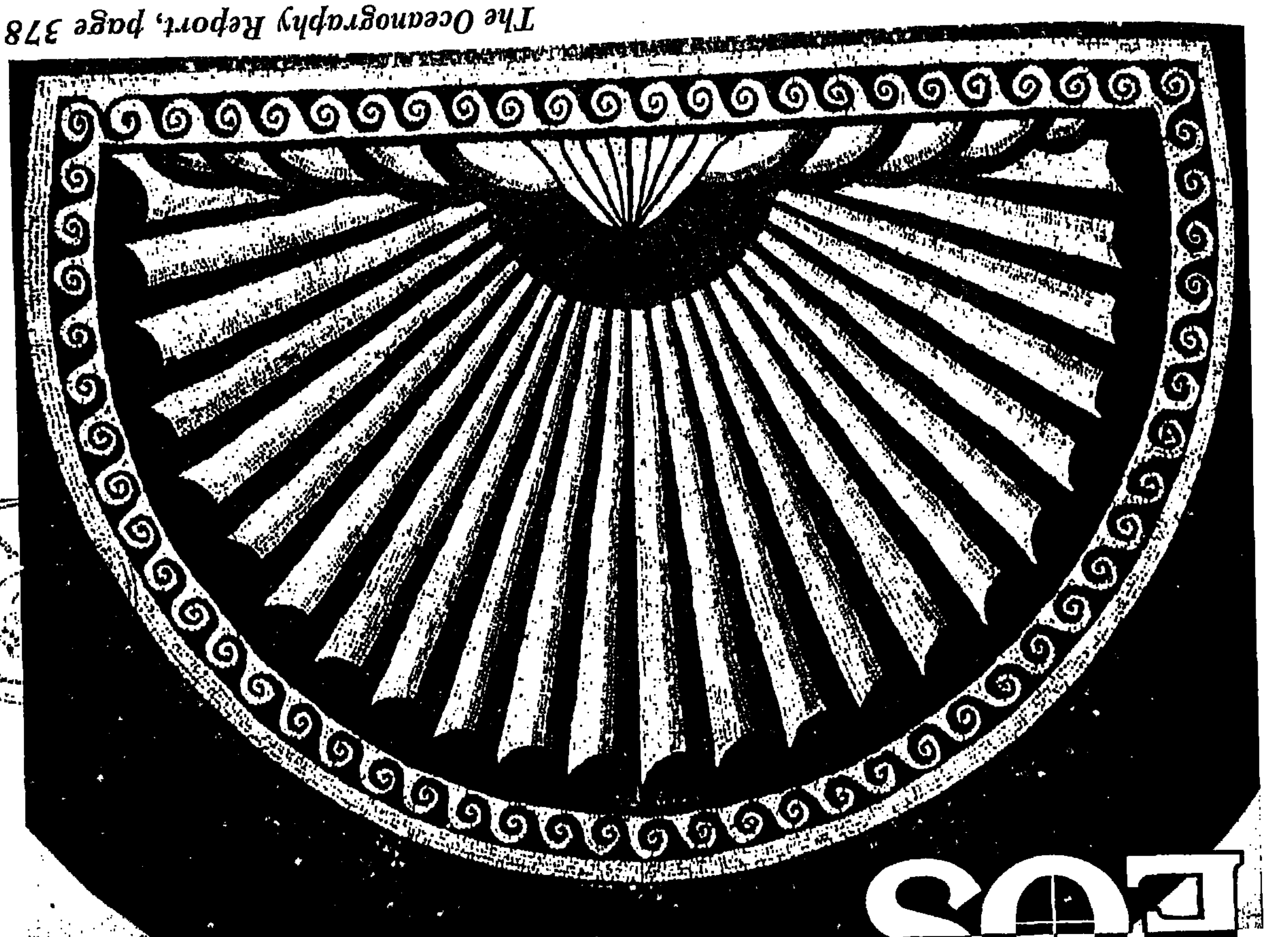

Eos Transactions, American Geophysical Union Vol. 65 No. 23 June 5, 1984

Eos, Transactions, American Geophysical Union Vol. 65, No. 23, Pages 377–392 June 5, 1984

Sadami Matsushita 1920–1984

Sadami Matsushita, of the National Center for Atmospheric Research, died on March 15, 1984, less than a half year after being told that he had stomach cancer. He was born in Kyoto, Japan, on February 12, 1920, the only son of Kiyomi and Taka Taniguchi Matsushita, from whom he acquired his lifelong appreciation of literature and the arts. In 1951, Matsushita obtained his Doctor of Sciences degree from Kyoto University where, continuing his research and lecturing, he soon became one of Japan's leading experts on the subject of ionospheric processes. In 1954, on an invitation from the Research Staff of Physics at the Imperial College of London, he spent a year in England. Before returning to his homeland, Matsushita was persuaded by Walter Roberts to visit the High Altitude Observatory (HAO) at the University of Colorado at Boulder, Colo. The visit became a permanent 29 years of significant scientific creativity at HAO (which became a part of the Center for Atmospheric Research).

Matsushita's 163 professional publications span 35 years of dedicated research. His specialty was the ionosphere, in particular *E* region ionization and currents; about two thirds of his publications were concerned with the associated geomagnetic topics. He was an editor of two major textbooks, *Ionospheric Sporadic E* (Pergamon Press, New York, 1962) and *Physics of Geomagnetic Phenomena* (Academic Press, New York, 1967). In a review of this latter book, E. C. Bullard wrote, "Those coming fresh to [geomagnetism] as young men, and their elders who have failed to keep up with current work, will be grateful." Matsushita contributed 17 chapters to various textbooks and encyclopedias. He was continually invited to review ionospheric and geomagnetic topics at international scientific meetings. He was an active leader in the International Association of Geomagnetism and Aeronomy, the International Scientific Radio Union, the American Geophysical Union, and the Society of Terrestrial Magnetism and Electricity of Japan. He was a fellow of the AAAS, a member of RESA and Sigma Xi, and editor of several scientific journals. For many years Matsushita was the principal organizer of the triennial International Symposium on Equatorial Aeronomy.

To many fellow scientists, Matsushita's greatest contribution was his dissection of the physical processes involved in the ionospheric composition, currents, fields, and motions. As part of his professor adjoint post at the University of Colorado Department of Astro-Geophysics, he guided a number of superior graduate students in their dissertations on these topics. Through their research his work continues and grows.

Matsushita's interests extended to Japanese art, music, and history. He was a translator of ancient Japanese writings. At times he advised the Colorado University College of Music concerning their productions involving Japanese costumes, dance, and customs. He enjoyed collecting antique Japanese arrowheads and associated martial artifacts and wrote scholarly articles regarding their classification and historical significance. He was occasionally asked to provide an authoritative appraisal of such items for museum collections. His great joy on weekends at international science conference trips was to discover a singular Japanese antique at some inconspicuous shop. His home in Boulder was almost a miniature museum for displaying his favorite acquisitions. Indicative of his values and sense of scientific continuity, however, was Matsushita's cherished office adornment: the chair used by Sydney Chapman during his last years at HAO.

Walter Roberts recalls that Mat ". . .was never too busy to give help and, in his critical but gentle way, he would tell me what he thought was right or wrong about the matter I was trying to comprehend." To all of us who knew him, Matsushita was not only a fine and productive scholar but unfailingly gracious and patient with those who sought knowledge or disagreed with his viewpoint. The world of his friends is now a little more empty with him gone. The world of geophysics has profited greatly by his dedicated lifetime.

Contributions to the tax exempt Matsushita Memorial Fund are being accepted c/o University Corporation for Atmospheric Research, D. A. Reynolds, Comptroller, Box 3000, Boulder, CO 80307. It is the purpose of this fund to publish a bound book of selected Matsushita research papers to distribute to all those who contribute $10 or more.

This tribute was contributed by Wallace H. Campbell, *Branch of Global Seismology and Geomagnetism, U.S. Geological Survey, Denver, CO 80225.*

News

Natural Gas: The Next Shortage

The eighth Annual Meeting of the Gas Research Institute that was held in Chicago in April 1984 focused on the potential of a crisis in the supply of natural gas. According to a report of discussions held at that meeting, "Natural gas, the country's largest petrochemical feedstock, may be in short supply in a couple of years if some present forecasts prove true. The next supply/demand crisis for natural gas is likely to come in early 1986" [*Chemical and Engineering News*, April 30, 1984]. There are a number of variables, geologic and socio-economic, that may affect this prediction. An important factor is that drilling exploration of natural gas has decreased sharply, due to the onset of sharp rates of surplus since 1981. Drilling is highly sensitive to depth and flow rate.

Since 1981, a number of gas wells have been shut down, a process that may have damaged their usability in the future. New drilling has been for relatively shallow holes that could run out of gas in the next 2 years. Future drilling depends a lot on demand, continuation of deregulation, and costs. The natural gas industry was granted a number of 6-year lease development awards for deep hosing drilling in the Gulf of Mexico. It will take considerable drilling effort to bring these leases into production by 1989, the year they expire. The question now is whether demand will be sufficient to provide the necessary funding.

The reason that a 1986 crisis is predicted by most (but not all) natural gas company executives and market analysts is that supply and demand are expected to balance out by late 1985. Shortages may begin early 1986. The price of natural gas is expected to rise sharply then, owing to shortages and to the phases of decontrol and deregulation of the industry. The status of wells that may have been damaged due to high pumping rates in the past may be a factor in 2 years. The reopening of shut-down wells may be another factor.

The sad outcome of the present circumstances is that not only will gas prices rise in 2 years, but higher prices will support imports again.—*PMB*

New Undersea Research Unit

The first cold-water activity under the National Oceanic and Atmospheric Administration's (NOAA) National Undersea Research Program will begin in the Gulf of Maine in August, according to NOAA Administrator John V. Byrne. The prime objective of the new activity will be to survey ocean dumping grounds and to study the productivity of the area's valuable fish resources. (The World Court is currently deciding on the fishing boundary between the United States and Canada in and around the Gulf of Maine.)

Detailed maps of dumpsites off Portland, Maine, and Boston, Mass., will be made, followed by an assessment of the effects dumping has on marine life. Dredge spoil is dumped offshore from Portland; a variety of material—from dredge spoil to munitions—is dumped off Boston.

The new undersea research unit will be operated for NOAA by the University of Connecticut.

Other facilities in NOAA's National Undersea Research Program include the Hydrolab habitat off St. Croix, operated by Fairleigh Dickinson University; the Southeastern Undersea Research Facility (SURF) with a diving bell and surface vessel, operated by universities from Virginia, North and South Carolina, and Georgia; and a University of Hawaii program that uses a small submersible.

Seismologists to Map the Mantle

A. Dziewonski and J. Woodhouse of Harvard University have developed new seismic models of the earth's mantle, according to a recent report. The calculations are the results of attempts to obtain three-dimensional seismic structures of the mantle. The formulations are mathematical fits to seismic data, essentially with no major initial assumptions as to mantle structure. That the model has features that correlate with known crustal and mantle properties has been reassuring. The report quotes Woodhouse, "This makes other patterns discovered in this study highly believable" (*Research and Development*, May 1984). A first finding of the model is related to the homogeneity question of the upper and lower mantle regions. Dziewonski said, ". . .at this point our maps show little continuity between the upper and lower mantles." Other findings of the new models involve the roots of continental structures, which in South America and Africa extend into the transition zone to depths of about 600 km.

The new models may be limited to previous compilations of the seismic properties of the mantle by Dziewonski and colleagues under the acronyms of PEM, PREM, etc. In PREM, which refers to the preliminary reference earth model, an attempt was made to develop a parameterized approach and, as in the field of geodesy, compare a reference model in analogy with the reference ellipsoid. The result has been met with broad acceptance. The analogy of attempting to parameterize normalized functions strictly holds true only in terms of seismic coefficients (Vp,Vs), and less so for (Qu,Qk). Radius must be obtained from geodesic models, and density must be fit to models of velocity gradient whose exactness varies, particularly at discontinuities where detailed data may be unavailable (A. M. Dziewonski and D. L. Anderson, *Physics of the Earth and Planetary Interiors, 25*, 1981). Among the revelations of PREM are interpretations that the low velocity zone in the upper mantle is probably due to anisotropy, the result of preferred orientation of mineral crystals (olivine and pyroxene). Thus, the low velocity zone may not be due to a heated zone as previously thought.

Anderson extended the model-making effort recently and called his approach "earth tomography" (See *Eos*, April 17, 1984, cover, and May 8, 1984, p. 346; also see *Science, 223*, 347–355, 1984). He described the analogy with medical practice as follows: ". . .technique similar to medical tomography being used for imaging with seismic body and surface waves." There is a departure from the PREM approach in that geochemical reasoning and calculated mineral properties were fed into the modeling procedure. A conclusion was drawn that olivine mineralogy (actually, olivine chemical component or stoichiometry) was not dominant in the earth as would be the result of having pyrolite model compositions in the mantle. According to Anderson, "The transition region, therefore, appears to be mainly garnetite, rather than olivine and its high pressure forms."

The consequences of this model and of PREM are that a number of standard assumptions about the earth's interior may be questioned. That the low velocity zone in the upper mantle is not a high-temperature zone could affect thermal models of upper mantle convection mechanisms, and that the 400-km seismic discontinuity is not mainly due to the olivine-spinel transition, and, indeed, may not be a valid discontinuity at all, could be difficult to accept in the context of familiar models of the transition zone. There is essentially no olivine-equivalent component in the transition zone and lower mantle, yielding a perovskite lower mantle that would mean that 80% of the earth's volume was made of silicate perovskite.

How are we to know how to interpret Dziewonski and Anderson's models and their soon-expected derivatives? Aside from pure reference data (i.e., seismic velocities coordinated with the earth's radial distances in three dimensions) the consequences are at present subject to the uniqueness of interpretation and to the validity of physical properties of mantle minerals calculated over great depths in the mantle. Ground truth (for these interpretations lies in extensive seismic data. Ground truth must also lie in valid mineral data for the intense conditions of the mantle. The newly emerging field of mineral physics will have to supply this truth.—*PMB*

Acid Rain Study in Gulf of Mexico

As part of the continuing investigation into the sources and mechanisms of acid rain, a research project sponsored by the National Oceanic and Atmospheric Administration (NOAA) will attempt this summer to find out if natural substances blowing inland from the Gulf of Mexico might be partly responsible for the acidic rain that afflicts the midwestern and eastern United States.

A research team flying a Beechcraft twin-engine airplane will sample air quality at various points offshore, along the Gulf Coast, and inland to measure concentrations of chemicals that are "acid precursors." These precursors—sulfate, sulfur-containing gases, and alkaline materials—form naturally in the Gulf, its estuaries and coastal wetlands, according to the project's principal investigator, Rudolf F. Pueschel of NOAA's Environmental Research Laboratories. The chemicals rise into the atmosphere and are carried inland by onshore winds; the NOAA study group would like to know more about their concentration as they move northward over the continent.

During periods in the summer when stalled high pressure areas in the Gulf and off the Atlantic coast of Florida are forcing air masses inland, the research airplane will fly sampling missions twice daily. The plane is outfitted for trace gas analysis, cloud and rainwater collection, and measurement of aerosol size distribution and elemental composition. The flights will run parallel to the coastline at a distance of roughly 30–50 km offshore, as well as along the coast and at various distances inland (depending on how long the winds blow onshore). Samples will also be taken from within offshore clouds to collect data on how these clouds accumulate chemical compounds from the water.

The flights will originate from points between Corpus Christi and Houston, Tex., and from Mobile, Ala., east across the Florida panhandle. "Selection of these areas [where onshore winds can blow for 2–3 days] followed examination of weather conditions in the Gulf for the past 5 years," according to Pueschel. The Gulf of Mexico study is part of the National Acid Precipitation Assessment Program, a multi-agency investigation of acid rain, and is being conducted by the Air Resources Laboratory, part of NOAA's Environmental Research Laboratories in Boulder, Colo.

In Congress: Upcoming Hearings

The following hearings and markups have been tentatively scheduled for the coming weeks by the House of Representatives. Dates and times should be verified with the committee or subcommittee holding the hearing or markup; all offices on Capitol Hill may be reached by telephoning 202-224-3121. For guidelines on contacting a member of Congress, see *AGU's Guide to Legislative Information and Contacts* (*Eos*, April 17, 1984, p. 159).

June 14: Conference committee on the **Export Administration Act** reauthorization (S. 979). Capitol Building, Room S-207, 2 P.M.

June 25: Hearing on the National **Minerals and Materials Policy** Coordination Act (H.R. 3717) by the Mining, Forest Management, and Bonneville Power Administration Subcommittee of the House Interior and Insular Affairs Committee. Longworth Building, Room 1324, 9:45 A.M.

June 26: Hearing on legislation subjecting the **Coastal Zone Management** Act (P.L. 94–370) to federal consistency provisions (H.R. 4589) by the House Merchant Marine and Fisheries Committee. Longworth Building, Room 1334, date and time tentative.—*BTR*

Mapping the EEZ

A cooperative, multi-year program to map the largely uncharted Exclusive Economic Zone (EEZ), begun last month, has the potential for piggybacking scientific observations and research. On March 10, 1983, President Ronald Reagan proclaimed the mineral-rich zone as the area between the U.S. shoreline and 200 nautical miles outward. The United States has sovereign rights for exploration, exploitation, conservation, and management of all living and nonliving resources within the zone.

The National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS) will cooperate in the project that will map an area nearly twice the area of U.S. land. USGS responsibilities include definition of seafloor geology and definition of geological processes and resources, including sand and gravel, placers, phosphorites, manganese nodules, cobalt crusts, and sulfides (*Eos*, March 20, 1984, p. 105). NOAA, meanwhile, will be surveying, mapping, analyzing resources, and managing fisheries.

Mapping began in the Pacific near Cape Mendocino, Calif. The west coast will be surveyed this year and next, followed by Alaska in 1986, the Hawaiian Islands in 1987, and the trust territories after that. No schedules have yet been set for the east and Gulf coasts.

NOAA and the USGS are encouraging the piggybacking of observations and sampling in related areas during the data-gathering cruises. For additional information, contact Adm. John Bossler, National Ocean Service, NOAA, 6001 Executive Blvd., Rockville, MD 20852, or Terry W. Offield, USGS, 915 National Center, Reston, VA 22092.—*BTR*

Books

Fundamental Concepts in the Numerical Solution of Differential Equations

J. F. Botha and G. F. Pinder, Wiley-Interscience, New York, 202 pp., 1983.

Reviewed by J. A. Liggett

This book is relatively short, about 200 pages, organized into seven chapters. The first chapter sets the scope and objectives and contains a note on notation. The next chapter contains the fundamental concepts that are the key to the presentation and the authors' philosophy on numerical methods. Chapters 4–6 treat elliptic (Poisson's equation), parabolic (the diffusion equation), and hyperbolic partial differential equations, respectively. The last chapter shows the solutions of certain cases with singularities and nonlinear behavior. The boundary element method is briefly discussed in chapter 4; the method of characteristics is discussed in chapter 6.

This book brings a much needed unifying point of view to the methods of finite differences and finite elements. The authors treat both methods from the perspective of using interpolating polynomials. The finite element method is solved only with the method of weighted residuals, which in turn uses only Galerkin and collocation techniques. It is refreshing that the book makes valid comparisons between finite differences and finite elements. Finite differences are not dead and are not to be completely replaced by finite elements. At the end of each chapter the authors provide a summary which covers the main conclusions of the chapter. This summary often points to the relative advantages and disadvantages of the methods in the chapter. This sort of guidance is, unfortunately, rare among books dealing with numerical methods, and its appearance in this book is most welcome.

There appears to be two kinds of books on numerical methods: the "how to" books that explain the elements of numerical solutions and attempt to instill an intuitive feel for the process and the "analysis" type that explains how numerical methods function on a mathematical basis. Most engineers and applied scientists have little time for the second type, perhaps to their detriment. This book appears to straddle the fence between these two types. How well the authors manage this balancing act is dependent on the reader's point of view. Few students who are learning numerical methods, especially with the goal of applying them to practical calculations, could appreciate detailed mathematical analysis. On the other hand, the analyst might become impatient with some of the elementary explanations. The book tends to be most valuable for those who already know practical numerical methods, especially those who learned it in a haphazard way, in that it unifies some of the techniques, compares methods, and puts them on a common ground. From that point of view I thoroughly enjoyed reading this book.

The authors state on the book cover that it can serve as a text in graduate or undergraduate courses or as a reference for engineers, research scientists, numerical analysts, and computer programmers. In serving that audience the book seems to have a number of shortcomings. It is written rather unevenly, assuming in some parts that the reader is a neophyte in numerical methods and mathematics, and in other parts that the reader has considerable knowledge. In separate places there are explanations of the classification of partial differential equations and Gaussian quadrature (without treating the significance of the former or the basis of the latter) which must be elementary to a student who could read and understand the difficult section on consistency, stability, and convergence. The authors point out that the book is free from specific engineering and scientific jargon but must compensate by including considerable mathematical jargon which will be a hindrance to most engineering and applied science students. There are examples in each chapter and problems at the ends of the chapters, but these are of a mathematical nature and would not serve to motivate the applied student. Early in chapter 2 there are two theorem-proofs (those most hated artifacts from some long forgotten mathematics course), but none in the remainder of the book.

The notation is a minor point but somewhat annoying in my reading of the book. Differentiation is symbolized by a capital *D* with a subscript denoting partial differentiation and a superscript denoting the order. I often found myself turning back pages to find the definition of symbols. In a few places the symbols appear to have multiple meaning. For example, the short section on Gaussian quadrature uses *A* for weights and *x* for sampling points, exactly the same as used in the immediately previous section for area and nodal coordinate. Also, on occasion some of the mathematical or numerical jargon is undefined or defined after the point of first usage. There are a number of places where the authors could have made the book more readable.

The reader must constantly keep in mind the limitations of this book. The authors have not attempted a comprehensive text in terms of problems, examples, or numerical techniques. That fact is apparent in the three chapters on elliptic, parabolic, and hyperbolic equations. It was most apparent to me in the hyperbolic chapter, which barely mentions in a single, unnumbered equation only one finite difference implicit scheme. The Galerkin method is deemed unsatisfactory for hyperbolic equations without mention of the Galerkin-Petrov technique. Reasonably frequent references to the literature do not compensate for the omissions.

Owing to the above mentioned limitations, I cannot recommend the book as a text, one of its stated objectives. I would, however, highly recommend it to those interested in, and with some previous knowledge of, numerical methods. It would, indeed, be a rare reader who would not learn and benefit from the authors' views.

J. A. Liggett is with the Department of Environmental Engineering, Cornell University, Ithaca, New York.

Arctic Energy Resources: Energy Research

Louis Rey (Ed.), vol. 2, Elsevier, New York, 1983, x + 366 pp., $78.75.

Reviewed by George Gryc

Arctic Energy Resources is a volume of 26 papers recording the proceedings of the Comite' Arctique International Conference, held at the Veritas Centre, Oslo, Norway, September 22–24, 1982. This was the fourth of a series of meetings on the Arctic organized by the Comite', an organization established in the Principality of Monaco with the active support of H.S.H. Prince Rainier III. The fourth Conference was opened by H.R.H. Crown Prins Harald of Norway, a noble beginning for a noble objective.

The North Polar Region has drawn world attention recently because of several large hydrocarbon and other mineral discoveries and because of major political and environmental actions in the North American Arctic. Since 1923 when Naval Petroleum Reserve number 4 (NPR-4) was established, northern Alaska has been considered a major petroleum province. It was first explored systematically with modern techniques from 1943 to 1953. In 1958, Alaska became a state, and both federal and state lands in northern Alaska were available for private exploration. Building on the knowledge base provided by the Pet-4 program and its spinoff research laboratory at Barrow, industry explored the area east of NPR-4 and discovered the largest hydrocarbon accumulation (9.6 bbl crude oil and 26 Tcf (trillion cubic feet) gas) in North America at Prudhoe Bay. Concerns for environmental impacts, including oil spills, led to the passing of the National Environmental Policy Act in 1969. In 1970, over 9 million acres were set aside, now known as the Arctic National Wildlife Range, and in 1971 the Alaska Native Claims Settlement Act was passed by the U.S. Congress. The Arab oil embargo of 1973 heightened the energy crisis and changed the economic basis for further exploration in the Arctic. The convergence of these events dramatically changed the balance of power and the pace of activity in the North American Arctic.

Since the Prudhoe Bay discovery, additional petroleum resources of a few billion barrels of crude oil and nearly 25 (Tcf) of gas have been discovered on the North Slope of Alaska and adjacent Canadian Arctic regions both onshore and offshore. Pet-4, now the National Petroleum Reserve in Alaska, has undergone another exploration program and has been opened to leasing. Base metal deposits have been produced in the Canadian Arctic for many years and a new world-class lead and zinc province has been delineated in the Brooks Range of Alaska. Coal resources on the North Slope may be equal to or exceed those of the rest of the United States combined. Proposals are being debated currently in the U.S. Congress that would establish a U.S. Arctic Science Policy and provide a mechanism for continuing research.

All of these events have had and continue to have worldwide impacts. Conferences such as the one recorded in this volume help identify problems and provide summaries of current knowledge of the Arctic.

Contributions to the conference came from nine nations and did not include the Soviet Union. These contributions cover nearly all aspects of the subject, ranging from history and philosophy to environmental ethics, from descriptive geology to plate tectonics theory, and from drill rigs to submarine tankers. This volume of state-of-the-art summary papers would be useful, particularly to government heads, politicians, managers, and other decisionmakers on Arctic issues. However, it would serve only as a beginning or review for the researcher with more focused interests.

The volume is organized in four parts that presumably parallel the sessions of the Conference; section I, Opening Session; section II, Occurrence of Energy Resources; section III, Technological/Economic Aspects of Exploration/Exploitation of Arctic Energy Resources; and section IV, Environmental and Social Impact. The papers in the first section by Louis Rey and Tore Gjelsvik are fascinating and very instructive. In about 25 pages they summarize the history, geology, resources, environmental problems, and socio-economic impacts of Arctic energy resources and development. Rey's encyclopedic grasp of a wide range of scientific disciplines and his telegraphic but nearly poetic writing style make for instructive and yet enjoyable reading. These papers should be required reading in the several seats of government, especially Washington, currently wrestling with questions of policy and operations in the Arctic.

Geologists and geophysicists will be interested mainly in section II, about 145 pages, in which five authors set the framework geology, describe the petroleum and coal reserves, and project the potential resources. The papers on Arctic North America and Greenland by Nassichuk and on the Soviet Arctic and Subarctic by Meyerhoff are particularly well done, with good illustrations. Although they are but brief summaries of very large areas, both have extensive and useful references for further reading. Meyerhoff, a U.S. consultant geologist, has prepared again an excellent summary of Soviet energy resources and related geology.

The next two sections, about half the volume, record 17 short papers on a wide range of technical (engineering), economic, environmental, and social aspects of Arctic energy resources. There is a little bit of everything, useful commentaries, but not summaries of any one subject. To be sure, these are all very important aspects of the problem and these papers do provide a wide-angle view with occasional highlights.

Arctic Energy Resources is a well-produced book with good quality paper, very legible type, and mostly good illustrations. As a library source book, it is worth the price.

George Gryc is with the U.S. Geological Survey, Menlo Park, CA 94025.

Chemical Hydrogeology

William Back and R. Allan Freeze (eds.), *Benchmark Pap. in Geol.*, vol. 73, Hutchinson Ross, Stroudsburg, Pa., xv + 416 pp., 1983.

Reviewed by C. W. Fetter, Jr.

We hydrogeologists have waited for many years and some 70 volumes of the series of *Benchmark Papers in Geology* (Hutchinson Ross) for a definitive review of the theoretical development of hydrogeology. Our patience has been rewarded with two volumes, *Physical Hydrogeology* (edited by R.A. Freeze and W. Back) and *Chemical Hydrogeology*). From a historical perspective, this appears to be a logical division of the subject. The two branches of hydrogeology evolved along separate pathways for many years. In the 1960's the influence of the groundwater flow regime on the geochemical nature of groundwater was first described in a qualitative way. In a 1970 Meinzer Award–winning paper, the synergisms of groundwater flow, chemical thermodynamics, and mineral equilibria were eloquently described by Back and Hanshaw. The 1970's saw mass transport equations developed whereby physical flow of groundwater and transport of conservative solutes were quantitatively linked. Current research driven by the need to understand contaminant transport and attenuation mechanisms in groundwater is so linking physical and chemical hydrogeology that future review volumes may not be so conveniently divisible as these.

Chemical Hydrogeology is divided into five sections, with a total of 29 papers reproduced, some in their entirety and others which have been excerpted. The papers include their original lists of references, although some citation lists have been shortened if only a part of the original paper was reproduced. Each section is prefaced by comments by the editors giving their perspective of the development of that particular aspect of chemical hydrogeology. These comment sections are richly endowed with references to papers, many of which can also be considered classics in the field. Some of these cited papers were too long to be included in the review volumes while others are important textbooks. All of the papers reproduced in *Chemical Hydrogeology* are related to North American studies.

Part I contains nine papers published during what the editors term the evolutionary period. An additional 11 papers are cited by the editors in their comments. The evolutionary period papers include those dealing with ways of representing the results of chemical analyses as well as presenting some basic hydrogeochemical reactions.

Part II deals with the occurrence and geochemical significance of salt water and contains seven selections. The editors have included a thorough discussion of the historical development of the body of knowledge in this subject, citing an additional 49 references. The topics of the papers include salt water intrusion, membrane properties of shale, saline water in marine sedimentary rocks, and geochemical reactions involving the mixing of fresh and saline waters.

Part III examines the equilibrium approach to the study of chemical hydrogeology. The revolutionary aspects of this topic are highlighted by six articles and backed up by 38 citations in the editors' comment section. The papers primarily examine carbonate equilibria but one paper addresses the equilibrium chemistry of iron. A computer program for calculating chemical equilibria is also described in one paper.

Isotopes in groundwater is the subject of part IV. Three papers are included, and they discuss carbon 14 dating of groundwater, stable isotope studies using hydrogen and oxygen, and studies involving the comparison of the ratio of tritium to stable oxygen isotopes. An additional 21 articles are cited by the editors.

Heat and mass transport in flowing groundwater form the basis for the fifth and final section of *Chemical Hydrogeology*. This section contains three papers and a portion of a review article. The editors cite 17 additional papers published between 1963 and 1976. This final section is an area of much current research interest to hydrogeologists. It brings us up to the summary of work which was done through about 1974. This lag in time is in keeping with the concept of the *Benchmark Paper* series, but it does leave the reader with the desire for some presentation of the most up-to-date knowledge in this area.

Chemical Hydrogeology accomplishes the goal of the editors to "present. . .papers that demonstrate the historical development of the science of chemical hydrogeology." The editors do note that "one topic of great significance to science and society not covered in sufficient detail is the chemical hydrogeology of contaminated systems." I concur with this assessment and regret that space for two or three seminal papers on this topic was not available. This would have nicely completed the section on heat and mass transport. Despite this shortcoming, *Chemical Hydrogeology* is an excellent review volume. It is suitable as a source book for graduate level seminars in chemical hydrogeology and as a reference volume on the shelves of professional hydrogeologists.

C. W. Fetter Jr. is with the University of Wisconsin, Oshkosh, WI 54901.

EOS
Transactions, American Geophysical Union
The Weekly Newspaper of Geophysics

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American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

Cover. This scanning electron micrograph shows an occurrence of framboidal magnetite in the Essebi CM carbonaceous meteorite. Notice that the magnetite crystals making up the framboid are very uniform in size, being 0.6–0.7 μm across. Although somewhat malformed, these crystals show well-developed crystal faces. Terrestrial framboids, both pyrite and iron oxides, seem to require low-temperature aqueous environment for formation. Similarly, the framboidal magnetite shown here and seen so far in only eight of the more than 2000 meteorites is thought to be the result of low-temperature alteration by liquid water of the carbonaceous meteorite parent body. The magnetite formation occurred very shortly after the formation of our solar system. This rare occurrence of a framboid along with other unusually magnetite morphologies in the Essebi, Bells, and Harripura CM carbonaceous chondrites were reported recently at the Fifteenth Lunar and Planetary Science Conference by M. Hyman and M. W. Rowe, Department of Chemistry, Texas A&M University, College Station, Texas, and E. B. Ledger, Department of Geology, Stephen F. Austin State University, Nacogdoches, Texas, who provided the cover photograph, and by A. M. Davis, James Franck Institute, University of Chicago, and E. Olsen, Department of Geology, Field Museum of Natural History, Chicago, Illinois. The bar is 10 μm long. (Photo courtesy of Marvin Rowe, Department of Chemistry, Texas A&M University, College Station, TX 77843.)

New Publications

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Accretion Tectonics in the Circum-Pacific Regions, M. Hashimoto and S. Uyeda (eds.), *Adv. in Earth and Planet. Sci.*, D. Reidel, Hingham, Mass., viii + 357 pp., 1983, $85.

Arc Volcanism: Physics and Tectonics, D. Shimozuru and I. Yokoyama (eds.), *Adv. in Earth and Planet. Sci.*, D. Reidel, Hingham, Mass., 263 pp., 1983, $65.

Astrophysics and Space Physics Reviews, vol. 2, R. A. Zvunyaev (ed.), Harwood, New York, viii + 449 pp., 1983, $85.

Atlas of Continental Displacement: 200 Million Years to the Present, H. G. Owen, *Cambridge Earth Sci. Ser.*, Cambridge Univ., New York, vii + 159 pp., 1983, $29.95.

Atmospheric Turbulence: Models and Methods for Engineering Applications, A. Panofsky and J. A. Dutton, J. Wiley & Sons, New York, xix + 397 pp., 1984, $49.95.

Carbon Dioxide: Current Views and Developments in Energy/Climate Research, W. Bach, A. J. Crane, A. L. Berger and A. Longhetto (eds.), D. Reidel, Hingham, Mass., xvii + 525 pp., 1983, $72.

Continental Basalts and Mantle Xenoliths, C. J. Hawkesworth and M. J. Norry (eds.), Shiva, London, viii + 272, 1983, £12.50.

Developments in Precambrian Geology 6: Iron Formation Facts and Problems, A. F. Trendall and R. C. Morris (eds.), Elsevier, New York, xiv + 558 pp., 1983, $106.

Early Proterozoic Geology of the Great Lakes Region, L. G. Medaris, Jr. (ed.), Geological Society of America, Boulder, v + 141 pp., 1983, $28.

Effluent Transport and Diffusion Models for the Coastal Zone, D. C. L. Lam, C. R. Murthy, and R. B. Simpson, *Lecture Notes on Coastal and Estuarine Stud.*, vol. 5, Springer-Verlag, New York, ix + 168 pp., 1984.

Energetic Ion Composition in the Earth's Magnetosphere, R. G. Johnson (ed.), *Adv. in Earth and Planet. Sci.*, D. Reidel, Hingham, Mass., vi + 438 pp., 1983, $93.50.

Engineers and Electrons: A Century of Electrical Progress, D. Ryder and G. Fink, IEEE, New York, xix + 251 pp., 1984, $29.95.

Epicenters of Northeastern United States and Southeastern Canada, Onshore and Offshore: Time Period 1534–1980, G. N. Nottis (ed.), *Map and Chart Ser. 38*, The State Education Department, Albany, N.Y., 39 pp., 1983.

Explosive Volcanism: Inception, Evolution, and Hazards, Geophysics Study Committee, Geophysics Research Forum, Commission on Physical Sciences, Mathematics, and Resources National Research Council, National Academy Press, Washington, D.C., xii + 176 pp., 1984, $24.50.

The First 25 Years in Space, A.A. Needell (Ed.), Smithsonian, Washington, D.C., xii + 152, 1983, $12.50.

Fundamentals of Meteorology (Ser. Ed.), L. J. Battan, Prentice-Hall, Englewood Cliffs, NJ, xii + 304 pp., 1984, $26.95.

Geochemical Aspects of Radioactive Waste Disposal, D. G. Brookins, Springer-Verlag, New York, xiii + 347 pp., 1984.

Great Lakes Ice Atlas, R. A. Assel, F. H. Quinn, G. A. Leshkevich, and S. J. Bolsenga, *NOAA Atlas Number 4*, Great Lakes Environmental Research Laboratory, Ann Arbor, v + 115 pp., 1983, $13.

Groundwater Contamination from Hazardous Wastes, Princeton University Water Resources Program, Prentice-Hall, Englewood Cliffs, NJ, xii + 163 pp., 1984, $27.95.

Groundwater Contamination: Studies in Geophysics, Geophysics Study Committee, Geophysics Research Forum, Commission on Physical Sciences, Mathematics, and Resources, National Research Council, National Academy Press, Washington, D.C., xii + 179 pp., 1984, $17.95.

Hidden Wealth, Mineral Exploration Techniques in Tropical Forest Areas, D. J. C. Laming and A. K. Gibbs (eds.), *AGID Rep. 7*, Cornell University, vii + 222 pp., Ithaca, N. Y., $27.50.

The History of the Earth's Crust, D. L. Eicher, A. L. McAlester and M. L. Sherman, *Foundations of Earth Science Ser.*, Prentice-Hall, Englewood Cliffs, NJ, 197 pp., 1984, $18.95.

Hydropower Engineering, C. C. Warnick, in collaboration with H. A. Mayo, Jr., J. L. Carson and L. H. Sheldon, Prentice-Hall, Englewood Cliffs, NJ, x + 326 pp., 1984.

The International Karakoram Project vol. 1, K. J. Miller (ed.), Cambridge Univ., New York, xxx + 412 pp., 1984, $79.50.

International Society for Rock Mechanics, International Congress on Rock Mechanics, vol. 1, Melbourne, xxx + 689 pp., 1983, $250.

International Society for Rock Mechanics, International Congress on Rock Mechanics, vol. 2, Melbourne, xxxiii, + 341 pp., 1983, $250.

The Legal Regime of Fisheries in the Caribbean Region, W. R. Edeson, and J. F. Pulvenis, *Lecture Notes on Coastal and Estuarine Stud.*, vol. 7, Springer-Verlag, New York, x + 204 pp., 1983.

Mesoscale Meteorology: Theories, Observations and Models, D. K. Lilly and T. Gal-Chen (Eds.), D. Reidel, Hingham, Mass., x + 781 pp., 1983, $88.

Sawkins, *Minerals and Rocks*, vol. 17, Springer-Verlag, New York, xiv + 325 pp., 1984, $38.

Migmatites, Melting and Metamorphism, M. P. Atherton and C. D. Gribble (eds.), Shiva, London, x + 326 pp., 1983, £25.

Mineralogy: Concepts and Principles, T. Zoltai and J. H. Stout, Burgess, Minneapolis, Minn., x + 505 pp., 1984.

Mount St. Helens: An Annotated Bibliography, C. D. Hamly and D. A. Tyckoson, Scarecrow, Metuchen, N.J., viii + 249 pp., 1984, $17.50.

Correction

In a previous New Publications list (*Eos*, January 17, 1984, p. 20), the price of *Solar-Terrestrial Physics* was incorrectly listed; it is $115. In the same list, *Man, A Geomorphological Agent*, should have shown Dov Nir as the author.

Classified

RATES PER LINE

Positions Available, Services, Supplies, Courses, and Announcements: first insertion $5.00, additional insertions $1.25.

Positions Wanted: first insertion $2.00, additional insertions $1.50.

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Replies to ads with box numbers should be addressed to Box ___, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, DC 20009.

For more information, call **202-462-6903 or toll free 800-424-2488.**

POSITIONS AVAILABLE

Postdoctoral Research Associate in Mineral Physics/Mineral Chemistry. Position available immediately for program involving experimental at SUNY Stony Brook and National Synchrotron Light Source, Brookhaven National Laboratory, on elasticity and crystal structures of minerals, particularly at high temperatures and pressures. Candidates should have a background in mineral physics/mineral chemistry, with demonstrated ability and experience in single-crystal X-ray diffraction techniques, computer programming, and/or synchrotron radiation experiments. Salary $20,000 for one year with possible renewal up to three years total. Send vita and two reference letters to: Professor D.J. Weidner, Department of Earth and Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794.

SUNY Stony Brook is an affirmative action/equal opportunity educator and employer. AK 113–84

Postdoctoral Fellow in Igneous Petrology. Available August 15, 1984; duration of 1–2 years. Areas of research include mineralogy/petrology/geochemistry of kimberlites and lunar rocks. A working knowledge of the electron microprobe is required. Please send resume, short summary of research goals and the names of three persons who may be contacted for recommendation to:

L.A. Taylor
University of Tennessee
Department of Geological Sciences
Knoxville, TN 37996
Telephone: 615-974-6015

Physicist/Computer Professionals. SSAI carries out hardware/software engineering support servies and R&D activities in various fields if applied physics and atmospheric sciences. We have contracts at NASA/NOAA/NAVY offices in metropolitan Washington, D.C., area. For our on-going projects, we need systems programmers/analysts/scientists to carry out numerical modeling and analysis Studies in the areas of satellite remote sensing, climate research, atmospheric sciences/meteorology, astronomy/astrophysics/radio-astronomy and planetary research. Applicants must have MS/PhD degrees and computational experience with large scale machines. Also, for a coming requirement in New York City SSAI is looking for a Project Manager and a Systems Manager with progressively responsible supervisory R&D experience with large-scale third fourth generation computer installation using IBM 3033/3081, AMDAHL or CDC systems. SSAI offers yearly bonuses and provides liberal fringe benefits. Please send your resume with salary history and references to: SCIENCE SYSTEMS AND APPLICATIONS, INC., 10210 Greenbelt Rd., Suite 640, Seabrook, MD 20706.

Postdoctoral Research Associate in Mineral Physics/Mineral Chemistry. Position available immediately for program involving experimental and theoretical crystal chemistry, particularly at high temperatures and pressures. Candidates should have a background in mineral physics/mineral chemistry, with demonstrated ability and experience in single-crystal X-ray diffraction techniques, computer programming and/or diamond anvil cell experiments. Salary $20,000 for one year with possible renewal up to three years total. Send vita and two reference letters to: Professor C.T. Prewitt, Department of Earth and Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794.

SUNY Stony Brook is an affirmative action/equal opportunity educator and employer. AK 114–84

Atmospheric Research Scientist. To work on federally funded projects involving (a) laboratory and field experiments and (b) literature and data review and assessment. Prefer an M.S. with research experience and peer reviewed publications or a Ph.D. in physical science or engineering. Prefer strong background in atmospheric chemistry (aerosols, gases, or precipitation) but water or soil chemists would be considered. Strong skills in oral and written presentation of research results are required. Position ideal for ambitious young professional interested in developing their own research area. Write Dr. Donald Gatz, Illinois State Water Survey, P.O. Box 5050, Station A, Champaign, IL 61820.

The University of Illinois is an Affirmative Action Equal Opportunity Employer.

University of Cambridge/Theoretical Seismologist. It is hoped soon to appoint a postdoctorate to work independently in the general field of theoretical seismology. An interest in seismic modelling and interpretation, particularly of body-waves, would be suitable. Stimulating environment with other theoretical, refraction, reflection and earthquake seismologists. University salary. Send curriculum vitae to Professor C.H. Chapman, Bullard Laboratories, Department of Earth Sciences, University of Cambridge, Madingley Road, Cambridge CB3 OEZ, England, by 31 July 1984.

Marine Organic Geochemist. The Department of Oceanography, Old Dominion University, seeks candidates for a newly created, tenure track assistant professor level positon in marine organic geochemistry. Specific research interest is open, although the major departmental emphasis is on coastal process. The successful candidate is expected to pursue a vigorous funded research program, and to teach graduate and/or undergraduate level courses in his/her field. A Ph.D. is required and post doctoral experience is desirable. The expanding Oceanography Department offers programs leading to the M.S. and Ph.D. degrees. It currently has 15 faculty positions, with three in chemical oceanography, 70 graduate students, and the appropriate facilities for many chemical studies. The position is available immediately. Applicants should submit vita, statement of research interests, and the names of three references by August 1, 1984 to: Gregory A. Cutter, Search Chairman, Department of Oceanography, Old Dominion University, Norfolk, VA 23508, 804-440-4285.

Old Dominion University is an affirmative action/equal opportunity institution.

Hydrogeologists/Consulting. The Bethesda, MD, office of Dames & Moore has career opportunities available in our expanding hazardous waste management group. We are looking for individuals at the entry level or with 4 to 10 years experience with the following qualifications: 1). Minimum of a B.S. in geology or hydrogeology, 2) Design and review of groundwater sampling and monitoring programs, 3) Groundwater modeling, 4) Analysis of contaminant transport, 5) Field experience, 6) Excellent communications skills. Interested applicants should forward resumes to: Dames & Moores, 7101 Wisconsin Avenue, Suite 700, Bethesda, MD 20814, Attn: HG.

Dames & Moore is an equal opportunity employer.

Texas A&M University/Seismic Stratigraphy. The Department of Oceanography in the College of Geosciences at Texas A&M University has an opening for a Ph.D. with specialization in the field of seismic stratigraphy. This tenure track position is at the assistant professor level. Salary is negotiable depending upon experience and qualifications. This position will be available pending final approval.

The successful applicant will be expected to teach undergraduate courses in general oceanography, a graduate course in seismic stratigraphy, and may develop graduate courses of his/her own design. He or she will also be expected to conduct a vigorous research program.

Applicants should submit a vita along with a letter describing his/her research and teaching goals and the names of five persons for reference to Professor Robert O. Reid, Head, Department of Oceanography, Texas A&M University, College Station, Texas 77843. The closing date for applications is 15 July 1984.

Texas A&M University is an affirmative action/equal opportunity employer.

Postdoctoral Research Associate Positions/Geophysics and Igneous Geochemistry. The University of Maine at Orono (UMO) has postdoctoral openings for a solid earth geophysicist and an igneous geochemist. We seek a geophysicist who wishes to advance fundamental understanding of past and current thermal histories of the Appalachian Orogen in New England and elsewhere. The geochemist would be expected to investigate volcanic and plutonic suites in the Appalachians in Maine and in other terranes. Current funding permits appointments for at least 12 months. Subject to arrival of anticipated funding, the appointments could be extended to two years. Both appointments could start as early as August 1, 1984. Excellent facilities for geothermal research, computer applications, petrologic research and geochronologic studies exist at UMO. Additionally, limited funds are available for travel and research, and the appointees will be encouraged to generate exterior support individually or through cooperation with existing faculty. Please send inquiries, a vita, a list of referees, and a description of research interests to Edward R. Decker or Daniel R. Lux, Department of Geological Sciences, 110 Boardman Hall, University of Maine at Orono, Orono, Maine 04469. Telephone calls may be made to 207-581-2152, and forwarded to Decker or Lux.

The University of Maine is an equal opportunity/affirmative action employer.

Postdoctoral Position/UCLA. Postdoctoral position in experimental geochemistry/petrology available immediately for research on upper-mantle or lower-crustal problems. Successful applicant will have a strong background in thermodynamics and petrology. Send application to Art Boettcher, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California 90024, telephone (213) 825-8866.

UCLA is an equal opportunity/affirmative action employer.

Senior or Senior Project Hydrogeologist/Hydrologist. A newly-formed hydrogeology and engineering consulting firm, The Mark Group, seeks a mature, experienced hydrogeologist or hydrologist for an immediate filling of a senior technical position in the Las Vegas office. Ongoing and projected investigations will emphasize water resources development, hazardous waste, and geotechnical engineering projects. Principal project work is in California, Nevada, and Arizona. Prefer applicants with minimum four years similar experience and M.S. degree from a recognized program. Strong written and verbal communication skills and overall initiative are required. Professional registration desirable. Please send resume, references, salary and bonus commensurate with training, experience, and productivity. Ownership participation anticipated. Send letter of interest, resume, sample key reports or reprints to:

Dr. Robert F. Kaufmann, Principal
The Mark Group
7263 West Coley Avenue
Las Vegas, Nevada 89117
702-873-7128

University of Arizona. The Department of Hydrology and Water Resources invites applications for a faculty position in water resources with emphasis on water policy and management. Candidates must have academic training and/or professional experience in water resources and, preferably, in water quality policy and planning. Appointment may be at the level of an assistant, associate, or full professor. Applications should be submitted by October 31, 1984.

Dr. Daniel D. Evans
Chairman, Search Committee
Department of Hydrology and Water Resources
University of Arizona
Tucson, AZ 85721
Telephone: 602-621-3131.

The University of Arizona is an affirmative action/equal opportunity employer.

Postdoctoral Research Positions in Planetary Atmospheres/Lunar and Planetary Laboratory, University of Arizona. Applications are invited for postdoctoral research positions at the Lunar and Planetary Laboratory, University of Arizona, in Tucson, Arizona. The two positions will involve research in planetary physics and analysis of UV data from the Voyager mission. Research opportunities for these positions include the bound and extended atmospheres and ionospheres of the giant planets and their satellites, the Io plasma torus, earth's atmosphere, the interstellar medium, and the atmosphere and ionosphere of Venus. Applicants should have a strong background in theory and data analysis. Physicists and astronomers are encouraged to apply. Curriculum vita, bibliography and three letters of reference should be sent by July 15, 1984, to Dr. A. L. Broadfoot, Lunar and Planetary Laboratory, University of Arizona, 3625 E. Ajo Way, Tucson, Arizona 85713.

The University of Arizona is an Equal Opportunity Employer.

Assistant Research Geophysicist. The Institute of Geophysics and Planetary Physics of the Ocean Research Division of the Scripps Institution of Oceanography are considering the appointment of an assistant research geophysicist, step 1 or 2, to join a research group conducting electromagnetic soundings of the ocean floor. Applicants should have experience with land and oceanic EM measurements, a demonstrated capacity to design and construct equipment, and the ability to carry out experiments at sea. A Ph.D. in geophysics or related sciences is required. Candidates should have some experience with the analysis and interpretation of EM data. Salary range is $25,100–$26,100. Applicants must submit a resume, copies of relevant publications, and the names of three references by 1 July 1984 to:

Dr. Alan Chave
University of California, San Diego
Institute of Geophysics and Planetary Physics
A-025
La Jolla, CA 92093.

The University of California is an affirmative ac-

Research Associate/Research Technician. The University of Maine at Orono (UMO) has an opening for a research associate/research technician who would work in a small geophysical group. We seek an individual who can use and maintain modern digital electronic equipment; for example, multichannel analysers, I/0 interfaces for microcomputers, digital plotters and digitizing tablets. Familiarity with BASIC and FORTRAN will be needed, and some geophysical field work may be required as part of the duties of the appointee. Current funding permits an appointment for at least 12 months. Subject to arrival of antichpated funding, the appontment period could be extended to two years, or longer. Call Edward R. Decker at 207-581-2158 or 207-581-2152 about the position. Otherwise, send inquiries, a vita and a list of at least three references to Edward R. Decker, Department of Geological Sciences, 110 Boardman Hall, University of Maine at Orono, Orono, ME 04469.

The University of Maine is an equal opportunity/affirmative action employer.

Research Associate/Brown University. Research Associate in Planetary Geology at Brown University, Providence, Rhode Island. Experience in geologic/geomorphic analysis of planetary images, study of surface geologic processes, computerized image processing, and/or quantitative geomorphology is desirable. Deadline for applications is June 30, 1984. Submit resume, names and addresses of three references to Dr. James Head, Box 1846, Brown University, Providence, RI 02912.

Brown University is an equal/opportunity affirmative action employer.

Research Assistant. Position available immediately for research program: Large-volume high-pressure synthesis, high-pressure X-ray diffraction experiments using the diamond-anvil cell and Brillouin spectroscopy. Candidates should have a background in crystallography, and/or mineral physics with demonstrated ability and experience in single-crystal X-ray diffraction techniques, computer programming, and diamond-anvil cell experiments. MS Degree or equivalent experience required. Salary: $16,000—$18,000 for one year with possible renewal. Send vita and two reference letters to: Professor C.T. Prewitt, Department of Earth and Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794.

SUNY Stony Brook is an affirmative action/equal opportunity employer. AK 118

Research Associate Position/University of Miami. The Division of Meteorology and Physical Oceanography, Rosenstiel School of Marine and Atmospheric Science, University of Miami, searches for a programmer/data analyst with several years of geophysical data analysis experience for processing and analysis of oceanographic data obtained by moored or shipboard instrumentation. Applicants should be experienced with FORTRAN and preferably also with the VAX-VMS system. Job duties may occasionally include participation in cruises. The successful applicant should have a Masters Degree in physical, mathematical or computer sciences. Application with curriculum vitae and names of three references should be sent to: Dr. Thomas N. Lee, Division of Meteorology and Physical Oceanography, Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, Florida 33149, by 15 June 1984.

The University of Miami is a Private, Independent, International University...

Research Associate/University of Maryland. The Space Physics Group of the Department of Physics and Astronomy has an opening for a Research Associate beginning as early as July 1, 1984 for an initial one-year period with high likelihood of extension. The position involves research on energetic particles of solar and interplanetary origin. Applicants should possess a Ph.D. in a relevant area of physics or astrophysics; relevant research experience is highly desirable. Inquiries and applications should be addressed to Professor Glenn M. Mason, Department of Physics and Astronomy, University of Maryland, College Park, MD 20742. Applicants should send a vita including complete bibliography and a description of research experience, and should arrange for the sending of at least three letters of reference.

The University of Maryland is an equal opportunity/affirmative action employer.

Hydrogeologist. Applications are invited for a non-tenure track academic research appointment in hydrogeology to be filled at the instructor or assistant professor level. This position will have broad research responsibilities in one or more of the following areas: regional and site-specific hydrogeological studies, hydrogeologic and hydrochemical aspects of surface coal mining and reclamation, and assessment of aquifer characteristics by aquifer testing and hydrochemical evaluations. The position entails considerable field work and will be located in Billings, Montana. Candidates must have a M.S. degree in hydrology or geology (Ph.D. preferred) and at least three years of hydrogeological experience, with emphasis on aquifer testing and related work. Knowledge of drilling and the geology of northeatern Montana preferred. The closing date for applications is June 22, 1984. Salary will be $24,000—$29,000/year depending upon education and experience. Applications with resume and names and telephone numbers of three references should be sent to: Director, Montana Bureau of Mines and Geology, Montana College of Mineral Science and Technology, Butte, MT 59701.

An EEO/AA Employer.

Engineering Positions. (Columbus, Ohio, Location) Battelle, one of the world's leading R&D organizations, has openings in its Office of Nuclear Waste Isolation for engineering staff supporting design and construction overview of the nuclear waste salt repository. Requirements include degree, preferably advanced, in appropriate discipline and prior experience in nuclear facility or heavy construction. Previous large project, and government experience and P.E. registration preferred. Specific openings are:

- Geotechnical/Civil/Mining Engineering (Ref. #115)
- Civil/Mining Engineering (Ref. #116)
- Mining Engineer (Ref. #120)
- Materials Sciences Project Manager (Ref. #048)
- Senior Statistician (Ref. #112)
- Senior Geologist/Geochemist (Ref. #111)

We offer a comprehensive benefits package and an excellent salary commensurate with your background.

If your qualifications are appropriate and you are interested in becoming a part of this important program, please send resume, referencing a specific position, to Box 023, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

Battelle
Project Management Division

Research Position-Space Physics/Rice University. The Space Physics and Astronomy Department at Rice University seeks applicants for one or more full-time research positions within the department. Successful applicant(s) will play key role(s) in the development of theoretical three-dimensional models of the Earth's electromagnetic field. Applicants should have knowledge of, and interest in, at least one of the following areas: solar-wind magnetosphere interactions, magnetosphere-ionosphere coupling, ionosphere-atmosphere coupling, collisionless plasma microphysics, atmospheric electricity. Experience and/or interest in numerical modeling is an important consideration.

Title and salary level commensurate with experience, ranging from one-year Research Associateship (renewable in subsequent years depending on performance) to open-ended Research Scientist appointment in the Center for Space Physics. Please send resume and names of three professional references to T. W. Hill or R. A. Wolf, Space Physics and Astronomy Dept., Rice University, Houston, TX 77251.

The University is an equal opportunity/affirmative action employer.

Micropalentologist/University of Puerto Rico, Mayaguez. Position open July 1, 1984. Assistant Professor level, tenure track, $17,820 per annum (9 months teaching). Ph.D. required. Duties will involve teaching at the graduate level courses in the discipline being considered here, supervising student research and conducting personal research.

Applicants should send curriculum vitae, a brief statement of teaching and research plans and three letters of recommendation to Chairman, Appointments Committee, Department of Marine Sciences, University of Puerto Rico, Mayaguez, P.R. 00708. Telephone 809-832-4040, ext. 3443.

Groundwater Modeling Position. Camp Dresser & Mckee Inc. has an immediate opening in its Boston (Headquarters) Office for a groundwater modeling engineer. Responsibilities for this position include technical direction and marketing of projects involving computer modeling of groundwater supply, contamination, and restoration. An M.S. in Hydrogeology or Water Resources and professional registration are required; a Ph.D. is preferred. A minimum of seven years experience in computer modeling of environmental problems with at least three-four years in the groundwater field is required. Exploratory field experience would be a difinite plus.

CDM is the largest consulting engineering firm specializing in environmental engineering and sciences in the U.S.

For immediate consideration send resume, salary history and requirements to: Camp Dresser & Mckee Inc., One Center Plaza, Boston, MA 02108 Attn: Dr. G.J. Vicens.

CDM is an equal opportunity employer.

STUDENT OPPORTUNITIES

Special Doctoral Research Assistantships. The Department of Oceanography of Old Dominion University has several special doctoral research assistantships available for Fall Semester, 1984 and 1985. These carry a stipend of $7,000 per academic year, renewable for three years. Applicants with M.S. degrees qualify for waiver of tuition. Students interested in obtaining the Ph.D. in the areas of biological, chemical, geological, or physical oceanography should send an introductory resume to Dr. Ronald E. Johnson, Graduate Program Director, Department of Oceanography, Old Dominion University, Norfolk, VA 23508.

Old Dominion University is an affirmative action/equal opportunity institution.

Meetings

Announcements

Call for Papers: 31st Pacific NW Regional Meeting

The 31st Pacific Northwest Regional Meeting of the American Geophysical Union will be held September 7–8, 1984, at Oregon State University, Corvallis, Oregon. The convenors are Robert A. Duncan and Shaul Levi. The meeting will comprise a large general session plus special symposia on the first report of *Alvin* submersible diving on the Juan de Fuca Ridge and continental margin of Oregon and Washington, volcanism and plate tectonic evolution of the Pacific Northwest, marine geology, and geophysics.

Deadline for abstracts is August 1, 1984. To submit an abstract, follow the standard AGU format printed in *Eos*, January 10, 1984, p. 15. If you require a sample of the format call the AGU Meetings Department at 202-462-6903. Please send original and two copies to Robert A. Duncan, PNAGU, College of Oceanography, Oregon State University, Corvallis, OR 97331 (telephone: 503-754-2296).

A bargain package for meals and accommodations is available through the university, and the sessions will be held on campus at the Stewart Conference Center.

Two field trips are planned to the Western and High Cascades of central Oregon. The first (September 6) will visit the Western Cascades, and the second (September 9, 10) will transect the Cascade Volcanic Arc from west to east. The cost of the field trips will be minimal, including transportation. Information on field trips and accommodation at the meeting will be provided to each registrant.

Registration for PNAGU is $15, and the registration deadline is August 15, 1984. For more information please contact Robert Duncan...

Groundwater Conference

July 23–24, 1984 Eastern Regional Groundwater Conference, Newton, Mass. Sponsor: National Water Well Association Technology Division. (Alice Vickerman, National Water Well Association, 500 W. Wilson Bridge Rd., Worthington, OH 43085; tel.: 614-846-9355.)

The conference will include sessions on groundwater contamination and remedial action; groundwater and contaminant flow through fractured rock; geophysics applied to groundwater investigation; and two general sessions.

Water Resources Management

July 29–31, 1984 Conference on Educational Prerequisites for Water Resources Management, Baton Rouge, La. Sponsor: Universities Council on Water Resources. (Yacov Haimes, Chairman, Systems Engineering Dept., Case Institute of Technology, Case Western Reserve University, Cleveland, OH 44106; tel.: 216-368-4492.)

The program and activities of the conference reflect two major topics: the growing concern over the impacts of the present state of education on water resource management, focusing on the ramifications of recent studies on education; and the growing challenges in water resource education focusing on a reexamination of the 1975 annual meeting, which had as its theme "The Challenge of Water Resource Education."

A trip to the Louisiana World Exposition in New Orleans, La., is being planned following the conference.

Moon's Origin

Oct. 13–16, 1984 Conference on the Origin of the Moon, Kona, Hawaii. Sponsors: Lunar and Planetary Institute, Division for ...

Meetings (cont. from p. 397)

Planetary Sciences of the American Astronomical Society. (Pam Jones, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.)

Abstracts are due July 15, 1984.

The goal of the conference is to assess present understanding of lunar, and hence planetary, formation. Tentative session topics for contributed talks include the chemical, petrologic, geophysical, and dynamical constraints that can be placed on the moon's origin; and new experiments and observations that could help constrain the origin of the moon.

A proceedings of the conference will be published in book form; papers will be due December 15, 1984.

Illinois Lakes and Watersheds

Nov. 8–9, 1984 Illinois Lake and Watershed Management Conference, Springfield, Ill. Sponsors: University of Illinois Water Resources Center, AWRA Illinois section, North American Lake Management Society. (Glenn Stout, Water Resources Center, University of Illinois at Urbana-Champaign, 2535 Hydrosystems Laboratory, 208 North Romine St., Urbana, IL 61801; tel.: 217-333-0536.)

The deadline for abstracts (to be submitted in triplicate) is July 13, 1984.

The conference is designed to bring together technical and nontechnical persons to facilitate protection and management of lake and watershed resources in Illinois. Contributed and invited papers will be presented on lake and watershed management techniques and experiences; initiation and implementation of lake and watershed management programs on the local level; costs and benefits of lake and watershed management; lake and watershed assessment and classification methods and results; reservoir design and operation to prevent problems; and research and program needs.

A proceedings of all papers will be published. Written papers should not exceed 10 double-spaced pages and should be submitted by October 15, 1984.

Urban Climatology

Nov. 26–30, 1984 WMO Technical Conference on Urban Climatology and its Applications With Special Regard to Tropical Areas, Mexico City. Sponsors: World Meteorological Organization, World Health Organization. (T. R. Oke, c/o World Climate Program Dept., World Meteorological Organization, 41, Giuseppe-Motta, Case postale No. 5, CH-1211 Geneva 20, Switzerland.)

Abstracts (less than 500 words) are due July 15, 1984.

Topics relevant to the meeting include all aspects of urban climatology (processes, effects, models, methods, case studies), especially those relating to urban applications (hazards, health, comfort, air pollution, energy and water conservation and use, for example) to urban planning (climate factors in siting, layout, and operation of settlements) and to tropical locations.

Meeting Report

Practical Approaches to Earthquake Prediction and Warning

The title chosen for this renewal of the U.S.-Japan prediction seminar series reflects optimism, perhaps more widespread in Japan than in the United States, that research on earthquake prediction has progressed to a stage at which it is appropriate to begin testing operational forecast systems. This is not to suggest that American researchers do not recognize very substantial gains in understanding earthquake processes and earthquake recurrence, but rather that we are at the point of initiating pilot prediction experiments rather than asserting that we are prepared to start making earthquake predictions in a routine mode.

For the sixth time since 1964, with support from the National Science Foundation and the Japan Society for the Promotion of Science, as well as substantial support from the U.S. Geological Survey (U.S.G.S.) for participation of a good representation of its own scientists, earthquake specialists from the two countries came together on November 7–11, 1983, to review progress of the recent past and share ideas about promising directions for future efforts. If one counts the 1980 Ewing symposium on prediction, sponsored by Lamont-Doherty Geological Observatory, which, though multinational, served the same purpose, one finds a continuity in these interchanges that has made them especially productive and stimulating for both scientific communities. The conveners this time were Chris Scholz, Lamont-Doherty, for the United States and Tsuneji Rikitake, Nihon University, for Japan.

The format of the seminar was similar to that of the past: 3 days of formal papers and discussions, followed by a field trip, this time a day and a half in Tsukuba Science City. In Tsukuba, the American delegation had the opportunity to visit the facilities and discuss their research with the staff members of the Geological Survey of Japan, the Geographical Survey Institute, the National Research Center for Disaster Prevention, and the International Institute for Seismology and Earthquake Engineering of the Building Research Institute.

Only some highlights of the meeting can be offered in this brief report. The papers presented will be published as a special issue of *Earthquakes Prediction Research.*

The participants left the seminar filled with enthusiasm that we have made real progress toward the goals of our prediction research programs. Though we seem far from being able to make highly accurate short-term predictions, we are able to give reliable assessments of the likelihood of occurrence of strong earthquakes in some seismic zones on a decade-long time scale. This advance, in turn, will make it possible for us to focus our efforts to do short-term predictions in those places where a major event is most likely within the foreseeable future. There is nothing to indicate that the search for an operational prediction technology will be other than a long, arduous research task.

Progress in understanding the seismic cycle, at least within plate boundary seismic zones, is reflected in the convergence of the processes called "seismic hazard assessment" and "long-term earthquake prediction." The former once implied the study of the seismic climatology of a region, leading to estimates of the strongest earthquakes to be expected and their average frequency of recurrence. Now the combination of geological evidence of prehistoric activity, historical records of earthquakes, observations of contemporary seismicity, and measurements of current crustal movements make possible rather detailed probabilistic statements, admittedly strongly model dependent, about specific future earthquakes. Such statements are the basis for planning both further scientific studies of the phenomena and disaster mitigation measures. More than half of the 38 research papers in the seminar were devoted to some aspect of such long-term predictions.

In addition to the seismological and geodetic observations related to identifying and evaluating regions of increased seismic potential (seismic gaps), a strong geological component was reflected in the papers presented. The pioneering work of American geologists like R. Wallace and K. Sieh has demonstrated the validity and the importance of the interpretation of the displacement history of a fault during the past few thousand years or more from geological evidence. An ambitious trenching program is in progress in Japan, and the data being acquired are being combined with evidence of Quaternary faulting to provide a basis for long-term predictions for the inland (intraplate) part of the country.

It has been found, for example, that the Tanna fault, at the northern end of the Izu Peninsula, ruptures with an average interval of 700 years, the last time in 1930. The Senya fault in north-central Honshu had not experienced a major break for at least 3000 years prior to the great earthquake of 1896. These numbers illustrate the extreme difficulty encountered in trying to narrow the time of occurrence of future intraplate events. Another study of Quaternary faulting has led to the conclusion that the familiar recurrence relation, $\log N = a - bM$, between cumulative number of earthquakes with magnitude greater than or equal to M and the magnitude, works for all of the seismicity in a region, but not for activity on an individual fault.

Kanamori addressed the question of the strong possibility of the occurrence of a strong earthquake in a subduction zone at which young lithosphere is being slowly subducted. He tested an empirical relation between earthquake magnitude, age of subducting seafloor, and rate of convergence for an "end member" event, the earthquake of May 26, 1983, off of the coast of Akita Prefecture, in the Sea of Japan. The fit of this event to the relationship has led him to speculate about the possibility of a very strong event, M8.5, in the zone of subduction of the Juan de Fuca Plate under Washington and Oregon. The interevent time for such an event, which seems to be hundreds of years if it could happen at all, depends strongly on the fraction of the relative plate motion that occurs as seismic rupture rather than aseismic slip.

Aki expressed optimism that a theory of earthquake prediction is about to emerge, in which tectonic loading rates, the friction law for faults and the distribution of heterogeneities along the fault surface (asperities and barriers) would all be taken into account. He emphasized the value of observations of changes in attenuation revealed by changes in the rate of decay of the codas of local earthquakes as evidence of the changes in the distribution of small-scale heterogeneities and therefore as an important precursor.

Estimates of probabilities of occurrence of great earthquakes along various portions of the San Andreas fault developed independently by the Lamont group and by the U.S.G.S. were reviewed. There is strong agreement that an earthquake in the M6.5 range is highly likely in the Parkfield region in the next 20 years, and the most likely place for a great earthquake in the next few decades is along the southeastern portion of the 1857 break. Ishibashi has proposed a "West Sagami Thrust," along which slip occurs with great regularity at about 70 year intervals, the last being in 1923. He postulates that slip on this plane precedes great earthquakes to the southwest, along the Suruga Bay thrust. His conclusion is that a large earthquake will occur on the West Sagami Thrust in the 1990's, followed by the expected great Tokai earthquake within a few years.

Ishibashi also introduced to the seminar an idea recently proposed by K. Nakamura: the plate boundary between the North American and Eurasian Plates passes through central Honshu, possibly along the Fossa Magna!

Localized deformations of the crust, observable by a variety of techniques, may be the key to future earthquake predictions. Geodetic methods for earthquake dynamics range from conventional surveying techniques through a variety of instruments for point measurements (tilt, strain, gravity) to space-based observations using long baseline interferometry and laser ranging to satellites. Most of the papers in this area emphasized measurement techniques rather than examples of field data. Y. Hagiwara did discuss the dependence of the rate of change of gravity with height on the mode of local uplift. M. Zoback related in situ stress measurements near the faults to observations of crustal deformations and associated seismicity.

Monitoring local seismicity has been one activity in prediction research for years. The series of papers on this subject emphasized efficiency of the operation, with digital data, rapid data transmission, and automatic event location as key elements in modern practice in both the United States and Japan.

Case histories of precursors are still the basis of the search for a practical prediction technology. Examples of precursors, some well documented, others more speculative, were offered in reviews by Yamakawa, Mogi, and Wyss. Quiescence as defined by Wyss, or Mogi's gap of the second, is still a promising precursor that is derived from the analysis of an earthquake catalog. Strain events, b value changes, and earthquakes swarms or clusters have all appeared as anomalies prior to larger events. Wyss has put together a carefully derived story of a number of precursors to the 1975 Hawaiian earthquake. This may well be the best case of observation of simultaneous precursors with enough backup information to provide a basis for understanding them. At the same time, Wyss points out that there were no clearly recognizable precursors in the data available for the 1979 Imperial Valley earthquake.

Although electrical resistivity and geomagnetic anomalies have not provided the powerful tool for prediction once anticipated, they are useful for outlining the details of faults. Yukutake associates a low resistivity within the fault zone with fracturing, with some combination of water content and higher temperature responsible for the anomalies. Because increased pore pressure has been associated with increased seismicity, an association of lowered resistivity with increased earthquake activity is suggested.

The outlook for a major seismic event or volcanism in the Long Valley region was discussed by Hill, with special attention to the focal mechanisms of some of the earthquakes. The first motion patterns do not fit a simple double couple pattern, and various explanations were offered (and aired subsequently in more detail at the AGU Fall Meeting).

The ambitious Japanese program of radon observations was described by Wakita. Some 25 sites are occupied by Tokyo University, the National Research Center for Disaster Prevention, and the Geological Survey of Japan. Meteorological factors and noise produced by pumping nearby wells serve to obscure possible precursory changes in the radon concentration. The most encouraging signal seen yet was the simultaneous change at three wells prior to a M6 event in August 1983, at distances of 80, 150, and 166 km. It cannot be claimed that radon is a highly reliable precursor. Continuous hydrogen measurements for prediction have been started by M. Sato, and he showed some brief hydrogen spikes before some earthquakes in Long Valley.

Four papers on various aspects of the sociological and public policy aspects of earthquake predictions and their potential use in earthquake preparedness programs were offered. Of particular interest is the work of a committee of the Earthquake Engineering Research Institute of the United States in trying to learn the lessons offered by Japanese experience with the Large-Scale Earthquake Countermeasures Act of 1978 and the various kinds of responses and preparations being made in anticipation of the projected great earthquake in the Tokai district.

An important lesson from this seminar is the value to any group of scientists of taking time out to synthesize the results of its recent work. We do too little of this, as we push ahead eagerly to the next step. The American participants certainly learned much from the carefully prepared summaries and reviews delivered by their countrymen, nominally for the benefit of the Japanese colleagues. Presumably, the Japanese attendees also learned from their close associates as well as from the Americans. Earthquake prediction is a tough problem in earth physics and chemistry. We are making progress, and the work done in the 6 years since the National Earthquake Hazards Reduction Program was started in the United States is paying off.

This meeting report was contributed by Carl Kisslinger, Cooperative Institute for Research in Environmental Sciences, University of Colorado at Boulder, Boulder, CO 80309.

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Electromagnetics

0773 Remote Sensing
DIURNAL VARIATIONS OF ATMOSPHERIC NITRIC OXIDE: GROUND-BASED INFRARED SPECTROSCOPIC MEASUREMENTS AND THEIR INTERPRETATION WITH TIME-DEPENDENT PHOTOCHEMICAL MODEL CALCULATIONS
C. P. Rinsland (NASA Langley Research Center, Mail Stop 401A, Hampton, Virginia 23665) R. E. Boughner, J. C. Larsen, G. M. Stokes, and J. W. Brault

Total vertical column amounts of NO have been derived from infrared solar absorption spectra recorded near sunrise and sunset with the 0.01-cm^{-1} resolution Fourier transform interferometer at the National Solar Observatory on Kitt Peak (elevation 2095 m, latitude 31.9° N) on February 23, 1981. The results show an increase in NO concentration in the morning, late afternoon values about 40% higher than in the morning, and a decrease in NO concentration prior to sunset. The measured diurnal changes in the total vertical column amounts are compared with values obtained from time-dependent photochemical calculations.

1410 Chemistry of the Atmosphere
DIURNAL VARIATIONS OF ATMOSPHERIC NITRIC OXIDE: GROUND-BASED INFRARED SPECTROSCOPIC MEASUREMENTS AND THEIR INTERPRETATION WITH TIME-DEPENDENT PHOTOCHEMICAL MODEL CALCULATIONS
See 0773 Remote Sensing
J. Geophys. Res., D, Paper 4D0787

0733 Remote Sensing
MICROWAVE MEASUREMENTS OF MOISTURE DISTRIBUTIONS IN THE UPPER SOIL PROFILE
A. A. Sadeghi (Agronomy Department, University of Arkansas, Fayetteville, AR 72701), G. D. Hancock, W. P. Waite, H. D. Scott, and J. A. Rand

Laboratory and field experiments were conducted to investigate the ability of microwave remote sensing systems to detect the moisture status of a silt loam soil exhibiting abrupt changes in moisture content near the surface. Reflectivity measurements at three profiles were made with a bistatic reflectometer operating over the frequency ranges of 1 to 2 GHz and 4 to 8 GHz. Measurements in the laboratory had good agreement with a two-layer reflectivity model. Measurements in the field showed good agreement with a five segment linear moisture profile. The model was used to estimate the depth of drying layers within the bare soil. (evaporation, drying soil, water content, radar).
Water Resour. Res., Paper 4W0478

Seismology

6950 Seismic Sources
FAULT BEHAVOIR AND CHARACTERISTIC EARTHQUAKES: EXAMPLES FROM THE WASATCH AND SAN ANDREAS FAULT ZONES
D. P. Schwartz (Woodward-Clyde Consultants, One Walnut Creek Center, Walnut Creek, CA 94596) and K. J. Coppersmith

Paleoseismological data for the Wasatch and San Andreas fault zones have led to the formulation of the characteristic earthquake model, which postulates that individual faults and fault segments tend to generate essentially same-size or characteristic earthquakes having a relatively narrow range of magnitudes near the maximum. Analysis of scarp-derived colluvium in trench exposures across the Wasatch fault provides estimates of the timing and displacement associated with individual surface faulting earthquakes. At all of the sites studied, the displacement per event has been consistently large; measured values range from 1.6 to 2.6 m and the average is about 2 m. On the basis of variability in the timing of individual events as well as changes in scarp morphology and fault geometry, six major segments are recognized along the Wasatch fault. Based on the most likely number of surface faulting events (18) that have occurred on segments of the Wasatch fault zone during the past 8,000 yr, an average recurrence interval of 400 to 666 yr with a preferred average of 444 yr is calculated for the entire zone. Geologic data on the distribution of slip associated with prehistoric earthquakes and slip rates along the south-central segment of the San Andreas fault suggest that the M8 1857 earthquake is a characteristic earthquake for this segment. Comparisons of earthquake recurrence relationships on both the Wasatch and San Andreas faults based on historical seismicity data and geologic data show that a linear (constant b-value) extrapolation of the cumulative recurrence curve from the smaller magnitudes leads to gross underestimates of the frequency of occurrence of the large or characteristic earthquakes. Only by assuming a low b-value in the moderate magnitude range can the seismicity data on small earthquakes be reconciled with geologic data on large earthquakes. The characteristic earthquake appears to be a fundamental aspect of the behavior of the Wasatch and San Andreas faults and may apply to many other faults as well. (characteristic earthquakes, earthquake recurrence, fault behavior, paleoseismicity)
J. Geophys. Res., B, Paper 4B0611

6960 Strong Motion and Shock Waves
SCALING OF GROUND MOTION PARAMETERS, STATE OF STRESS AND FOCAL DEPTH
A. McGarr (U.S. Geological Survey, 345 Middlefield Rd., MS 977, Menlo Park, CA 94025)

The ground motion parameters Rv and ρRa, where R is hypocentral distance, v is peak velocity, ρ is density and a is peak acceleration, are found observationally to be strong functions of stress state and linearly related to focal depth z. If the stress state and focal depth are properly taken into account then the ground motion parameters depend on the seismic moment M_0 as expected from basic scaling principles. That is, $Rv \propto M_0^{1/3}$ and ρRa is independent of earthquake size. Regression lines fit to observations, covering broad ranges in seismic moment and focal depth, indicate that for extensional and compressional tectonic regimes, corresponding to normal and thrust or reverse faulting earthquakes, respectively, peak acceleration is given by

Normal: $\rho a_g = -1.08 \text{ MPa} + 1.06 \text{ (MPa/km)} z$

Thrust: $\rho a_g = 5.65 \text{ MPa} + 8.76 \text{ (MPa/km)} z$

and for peak velocity

Normal: $Rv/M_0^{1/3} = 10^{-4}(m^2/sec)(N\text{-}m)^{-1/3}[3.00+0.69(km^{-1})z]$

Thrust: $Rv/M_0^{1/3} = 10^{-4}(m^2/sec)(N\text{-}m)^{-1/3}[4.53+1.82(km^{-1})z]$

For strike slip earthquakes the data currently are insufficient to define regression fits but such lines would definitely lie between those for the normal and thrust stress regimes. These equations are appropriate for ground motion at small hypocentral distance as recorded in a whole space. It follows that for comparable focal depth, peak acceleration in a compressional tectonic regime, for example, much of the eastern United States, is a factor of about three greater than in an extensional regime, such as Nevada, and for peak velocity a similar comparison yields a factor of two difference. The similarity in behavior of the peak acceleration parameter to crustal strength, estimated from Byerlee's law of friction, with respect to depth and stress state, indicates that crustal strength is probably the factor governing the seismic source processes that give rise to the high-frequency peak ground motion. Analysis of the peak acceleration data in the context of crustal strength suggests bounds on the ground motion parameters, as recorded at a typical surface site, that depend on stress state; specifically, a (normal) ≤ 0.5 g and a (thrust) ≤ 1.9 g. Thus, the state of stress, as well as the focal depth, clearly is an important factor to be taken into account in the prediction of seismic ground motion.
J. Geophys. Res., B, Paper 4B0606

Social Sciences

7310 Economics (Federal water projects)
COST SHARING WITH IRRIGATED AGRICULTURE: PROMISE VERSUS PERFORMANCE
D. B. Franklin and K. H. Hageman (Economics Department, San Diego State University, San Diego, California, 92182)

Financial data from various federal water projects is analyzed to determine the extent of the deviation between projected private user cost sharing and actual payments collected. Evidence is presented which shows that irrigated agriculture is heavily subsidized not only with respect to capital expenditures but also for operation, maintenance and replacement costs. The latter result is especially surprising since agricultural users are required to pay 100% of their allocated share of annual O&M costs. Since actual user payments are found to fall far short of those projected in water project feasibility reports, reasons for the deviation are explored.
Water Resour. Res., Paper 4W0646

Solar Physics, Astrophysics, and Astronomy

7720 Electromagnetic Radiation
SOLAR ULTRAVIOLET VARIATION BETWEEN 1977 AND 1983
L. A. Hall (Air Force Geophysics Laboratory, Bedford, Massachusetts, 01731) and G. P. Anderson

A fifth measurement of the solar ultraviolet irradiance at 40 km in the stratosphere has been added to four earlier ones. It confirms the previously published conclusion that photospheric solar irradiance in the range 2350-2870A has been essentially constant during the current solar activity cycle. Chromospheric emissions seen in the MgII line cores increased during rising activity and decreased again as the activity declined. (Solar ultraviolet, solar irradiance, solar variation).
J. Geophys. Res., D, Paper 4D0405

Tectonophysics

8150 Plate Tectonics
FACTORS AFFECTING SEISMIC MOMENT RELEASE RATES IN SUBDUCTION ZONES
Eric T. Peterson (Department of Geophysics, Stanford University, Stanford, California, 94305) and Tetsuzo Seno

The amount of shallow seismic activity in subduction zones varies greatly from region to region. We quantify this seismicity by calculating seismic moment release rates and seismic slip rates for 24 subduction zones. To calculate the moment release, we sum the seismic moment for all interplate thrust-type events with surface wave magnitude $M_s \geq 7.0$, occurring from 1904 to 1980. We present a time-history plot of the seismic moment release for each subduction zone; these exhibit the differences in the seismic release patterns. For subduction zones where the time window of our study is not representative, the total moment release is corrected using information on repeat times. The moment release rates are compared with various subduction parameters in order to determine which factors influence the degree of coupling. These parameters include the age of the subducting lithosphere, absolute velocities of the upper and subducting plates, convergence velocity, and length, maximum depth, and dip of the Wadati-Benioff zone.

The moment release rate decreases as the age of the subducting lithosphere increases, when the zones belonging to a single subducting plate are considered. This age-versus-moment-release relation is consistent for the zones in which the Pacific, Cocos, Philippine Sea, and Indian plates are subducting. The moment release rates for the subduction zones in which the Pacific plate is subducting are much higher than for zones of other plates with similar age. The age-versus-moment-release relation holds among the zones which belong to one subducting plate; however, zones with similar ages but belonging to different plates do not have the same moment release rates. This suggests that within a single plate, the age is the dominating factor affecting the strength of seismic coupling, but that each plate as a whole has a characteristic moment release budget. Zones with retreating upper plates tend to have lower moment release rates. The moment release rate does not increase with convergence velocity; no simple relationship was found between these two parameters. The moment release rates depend most clearly on the age of the subducting lithosphere and the absolute velocity of the upper plate. These are the two independent subduction zone parameters among the variables considered. The other variables depend on these two parameters.
J. Geophys. Res., B, Paper 4B0608

8150 Tectonophysics (Plate Tectonics)
FLORIDA: A JURASSIC TRANSFORM PLATE BOUNDARY
Kim D. Klitgord (U.S. Geological Survey, Woods Hole, MA 02543), Peter Popenoe and Hans Schouten

Magnetic, gravity, seismic, and deep drill-hole data integrated with plate tectonic reconstructions substantiate the existence of a transform plate boundary across southern Florida during the Jurassic. On the basis of this integrated suite of data, the pre-Cretaceous Florida-Bahamas region can be divided into the pre-Jurassic North American plate, Jurassic marginal rift basins, and a broad Jurassic transform zone including stranded blocks of pre-Mesozoic continental crust. Major tectonic units include: the Paleozoic Suwannee basin in northern Florida, a central Florida Paleozoic basement complex, the West Florida platform composed of stranded blocks of continental crust, the Late Triassic South Georgia rift, the Late Triassic-Jurassic age Apalachicola rift basin, and the Jurassic-age South Florida, Bahamas, and Blake Plateau marginal rift basins. The major tectonic units are bounded by basement hinge zones and fracture zones (FZ). The basement hinge zone represents the block-faulted edge of the North American plate, separating Paleozoic and older crustal rocks from Jurassic rifted crust beneath the marginal basins. Fracture zones separate Mesozoic marginal sedimentary basins and include the Blake Spur FZ, Jacksonville FZ, Bahamas FZ, and Cuba FZ, bounding the Blake Plateau, Bahamas, South Florida, and southeastern Gulf of Mexico basins. The Bahamas FZ is the most important of all these features because its northwest extension coincides with the Gulf basin marginal fault zone, forming the southern edge of the North American plate during the Jurassic. The limited space between the North American and the South American/African plates requires that the Jurassic transform zone, connecting between the Central Atlantic and the Gulf of Mexico spreading systems, was located between the Bahamas and Cuba FZ's in the region of southern Florida. Our plate reconstructions combined with chrono-stratigraphic and lithostratigraphic information for the Gulf of Mexico, southern Florida, and the Bahamas indicate that the Gulf was sealed off from the Atlantic waters until Callovian time by an elevated Florida-Bahamas region. Restricted influx of waters started in Callovian as a plate reorganization and increased plate separation between North America and South America/Africa produced waterways into the Gulf of Mexico from the Pacific and possibly from the Atlantic.
(Magnetic Anomalies, gravity anomalies, drill-hole data, plate reconstructions).
1950, 2540, 8170, 9270.
J. Geophys. Res., B, Paper 4B0603

8150 Plate tectonics
RECENT MOVEMENTS OF THE JUAN DE FUCA PLATE SYSTEM
Robin Riddihough (Pacific Geoscience Centre, Box 6000, Sidney, B.C. V8L 4B2, Canada)

Analysis of the magnetic anomalies of the Juan de Fuca plate system allows instantaneous poles of relative rotation to be calculated for the last 7 Ma. The resulting plate motion sequence shows that both 'absolute' motions and motions relative to America are characterized by slower velocities where younger material enters the subduction zone - 'pivoting subduction'. The resistance provided by the youngest portion of the Juan de Fuca plate apparently resulted in its detachment at 4 Ma B.P. as the independent Explorer plate. Relative to the hotspot framework, this plate almost immediately began to rotate clockwise about a pole close to itself such that its translational movement into the mantle virtually ceased. After 4 Ma B.P., the remainder of the Juan de Fuca plate adjusted its motion in response to the fact that the youngest material entering the subduction zone was now to the south. (Plate motions, magnetic anomalies, subduction.)
J. Geophys. Res., B, Paper 4B0686

Journal of Geophysical Research

Volume 89 Number B6 June 10, 1984

Chemical Effects of Water on the Strength and Deformation of Crustal Rocks S. H. Kirby and C. H. Scholz, Guest Associate Editors and Workshop Co-Convenors

Regular Issue